Is it possible to extract infiltration rates from variable inflow furrow irrigation?

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Introduction

Furrow irrigation optimisation generally requires the use of numerical models such as SIRMOD to simulate various field management configurations. In most cases significant improvements in efficiency are possible through relatively minor alterations in field management. Initially these models require calibration so that they can predict the actual application. To a large extent the required information can be directly measured in the field but arguably the most important data, the soil intake rate is commonly estimated using inverse solution techniques. Typically these procedures use the advance data (distance and time measurements of the wetting front) to arrive at a time-dependant infiltration function. For simplicity the volume balance is the model of choice but introduces many limitations such as the assumption of constant inflow.

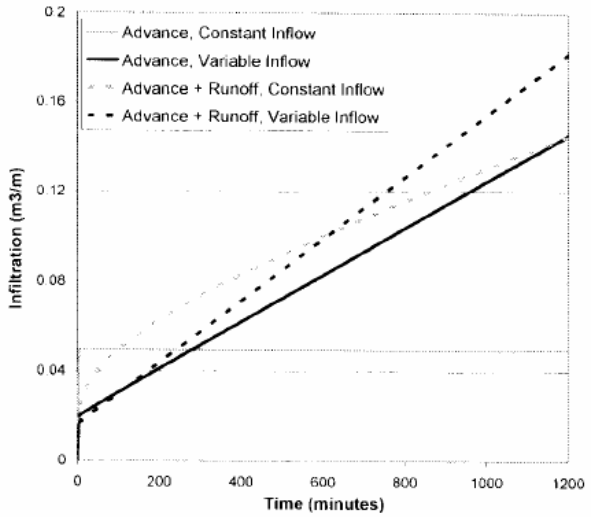
Model Development

A computer program, IPARM (Infiltration Parameters from Advance and Runoff Model) was developed based on proven procedures included in traditional infiltration from advance schemes (Gillies and Smith 2005) IPARM offers improved estimates for the infiltration function where reliable runoff data is available.

Gillies et al. (2006) altered the volume balance equation to accommodate variable inflow by utilising cumulative inflow volumes rather than the constant inflow rate. Secondly the volume temporally stored on the soil surface is allowed to fluctuate according to the instantaneous flow rate. IPARM attempts to match the simulated advance distances and runoff volumes to the measured values by altering the three parameters of the infiltration equation. The technique requires advance data (in the form of distance and time measurements) inflow measurements (discharge at any number of times) and runoff data where available. Other data requirements include the field slope, furrow geometry and upstream flow depth.

Results/Discussion

The procedure was evaluated by calculating infiltration parameters using both the average inflow and the full inflow hydrograph. The variable inflow approach performs well in situations where the temporal rate of change is gradual. Where the inflow rate changes throughout the event the resulting estimated infiltration functions will differ (Fig.1). In general the constant inflow assumption will introduce a systematic error into the estimated infiltration function. The nature of the error will depend on the shape of the actual hydrograph.



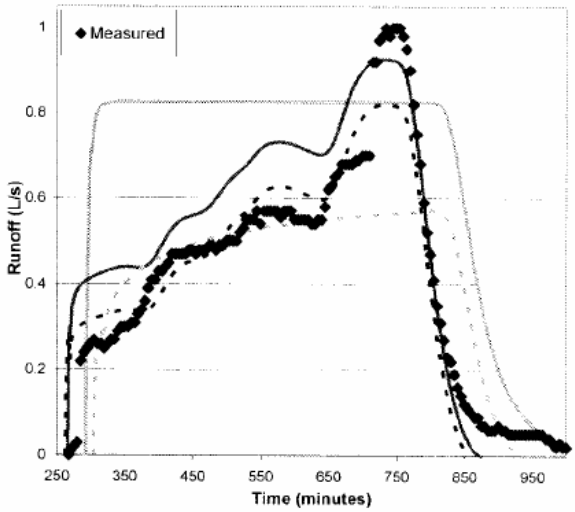


Fig.1 - Infiltration estimated by IPARM. Fig.2 - Simulated runoff using infiltration from Fig. 1.

The simulation model, SIRMOD was used to assess the ability of each set of infiltration parameters to re-produce measured advance trajectories and runoff hydrographs (Fig. 2). The inclusion of the variable inflow information improved the estimates of both total runoff volumes and shapes of the outflow hydrographs. Simulations that can more accurately re-produce field measurements should also offer better predictions of performance indicators such as application efficiency and distribution uniformity. In the illustrated example the actual application efficiency is 52% while the predicted efficiencies using infiltration information in Fig.1 were 24%, 45%, 55% and 51% respectively.

Further testing with a number of data sets collected within the same field indicated that some of the apparent variation in infiltration between furrows can be attributed to the failure to account for variations in the inflow rate.

Conclusions

The traditional inverse volume balance approach to estimate infiltration parameters was altered to accommodate a variable inflow rate. The IPARM model offers significant improvements when applied to gradually varying inflow hydrographs. Simulations conducted using the resulting infiltration information offer improved predictions of field measurements and therefore more accurate field performance indicators. IPARM uses simple but proven techniques to estimate soil infiltration rates from either advance and/or advance and runoff data and will accommodate the full inflow hydrograph.

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References

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